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Contents

PAGE

FACTORS AFFECTING THE DISTRIBUTION OF PONDEROSA AND JEFFREY PINES IN CALIFORNIA, *John R. Haller* 65

VIVIPARY IN CORDYLINE AUSTRALIS HOOK., *Howard J. Arnott* 71

STUDIES ON SECOTIACEOUS FUNGI VI. SETCHELLIOGASTER POUZAR, *Rolf Singer* and *Alexander H. Smith* 73

CEANOTHUS SEEDS AND SEEDLINGS ON BURNS, *Clarence R. Quick* 79

CHROMOSOME NUMBERS OF CALIFORNIA PLANTS, WITH NOTES ON SOME CASES OF CYTOLOGICAL INTEREST, *Richard Snow* 81

CHROMOSOME COUNTS IN THE GENUS GAYOPHYTUM, *David G. Dixon* 90

REVIEWS: Clara Chapman Hill, *Spring Flowers of the Lower Columbia Valley* (Robert Ornduff); Lloyd H. Shinners, *Spring Flora of the Dallas-Fort Worth Area, Texas* (Rogers McVaugh) 94

NOTES AND NEWS: ALLIARIA OFFICINALIS ANDRZ. IN OREGON, *Robert Ornduff* 96

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FACTORS AFFECTING THE DISTRIBUTION OF PONDEROSA AND JEFFREY PINES IN CALIFORNIA

JOHN R. HALLER

Pinus ponderosa Dougl. and *P. jeffreyi* Murr. are among the most widely distributed forest trees in California and are well known to western botanists. They are very closely related, and various authors have treated them either as species (Sudworth, 1908; McMinn, 1951) or as varieties of a single species (Shaw, 1914; Jepson, 1925). However, after extensive field investigations (Haller, 1957) the details of which will be published elsewhere, I am convinced that *P. ponderosa* and *P. jeffreyi* are well defined species, and I shall treat them as such in this paper. All of the observations which follow are my own, unless otherwise noted, and were made in connection with the taxonomic study referred to above.

In California, *Pinus ponderosa* occurs from the Oregon border south along the Cascade Range and the western slope of the Sierra Nevada in an uninterrupted belt over 400 miles long and about 25 miles in width. Throughout this belt *P. ponderosa* is a conspicuous element in a forest rich in coniferous species. It is also common on the higher coastal-facing slopes of the mountains of southern California as far south as Cuyamaca Lake in San Diego County, and occurs sporadically in the Coast Ranges, especially north of San Francisco Bay.

The distribution of *P. jeffreyi* roughly parallels that of *P. ponderosa* in California, but *P. jeffreyi* is relatively more abundant in the south, and extends beyond the range of *P. ponderosa* into the higher mountains of northern Baja California, Mexico.

Although the ranges of *P. ponderosa* and *P. jeffreyi* in California nearly coincide in the broadest geographical sense, and although both are often found at the same locality, the two species characteristically occupy different habitats. *Pinus ponderosa* occupies the lower coastal-facing slopes of the mountains, whereas *P. jeffreyi* is usually found on the higher coastal or desert-facing slopes. The altitudinal ranges of *P. ponderosa* and *P. jeffreyi* shift gradually higher from north to south in California, just as do vegetation zones in general. However, the degree of shifting is not the same in both species. The lower limit of the *P. ponderosa* zone rises steeply from north to south. In the north, near Mount Shasta, the lower limit of *P. ponderosa* is about 1000 feet, but in the south, near Barton Flats in the San Bernardino Mountains, it is at 5000 feet (fig. 1). The upper limit of the *P. ponderosa* zone does not rise as steeply. It changes from about 5000 feet in the north to 7000 or 7500 feet in the south. Therefore, the altitudinal range of *P. ponderosa* contracts from about 4000 feet near Mount Shasta to little more than 2000 feet at Barton Flats. South of the Barton Flats area *P. ponderosa* becomes rapidly more infrequent in the

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MADROÑO, Vol. 15, No. 3, pp. 65–96. July 20, 1959.

montane forest, until the most southerly stand is reached at Cuyamaca Lake, at the unusually low altitude of 4600 feet.

The lower edge of the *P. jeffreyi* zone rises from about 5000 feet near Mount Shasta to only a little over 6000 feet near Barton Flats (fig. 1). The zone in which *P. ponderosa* and *P. jeffreyi* overlap is consequently broader in the south than in the north, and stands comprised of both species are extensive near Barton Flats but highly restricted near Mount Shasta (Wiggins, 1940 and my own observations).[1] However, there are numerous localities throughout the state such as Shasta Valley in Siskiyou County and Pine Valley in southern San Diego County where *P. jeffreyi* occurs much lower, either with or without *P. ponderosa,* in what would usually be the lower portion of the *P. ponderosa* zone. The upper limit of *P. jeffreyi* rises from about 7500 feet near Mount Shasta to 9500 or 10,000 feet near Barton Flats. Thus the normal altitudinal range of *P. jeffreyi* increases from about 2500 feet in the north to 3500 or 4000 feet in the south.

What are the factors that cause this narrowing of the altitudinal range of *P. ponderosa* and broadening of the altitudinal range of *P. jeffreyi* in the south? There is both experimental and observational evidence which indicates that moisture at the lower altitudinal limit and temperature at the upper limit are usually the critical factors. Daubenmire (1943) has shown experimentally that seedlings of several important species of Rocky Mountain conifers, including *P. ponderosa,* are capable of withstanding much higher soil temperatures than those in their natural environments, but that they quickly succumb to drought conditions more severe than those in their natural habitats. In most areas of California also, *P. ponderosa* is probably restricted at its lower limit by moisture rather than temperature or some other factor. *Pinus ponderosa* is rarely found in areas with less than 25 inches of annual precipitation except near permanent sources of water. Of course moisture alone may not always be the limiting factor at low elevations. For example, in some localities where precipitation is still adequate but almost limiting, *P. ponderosa* might be held in check by its inability to compete with the more xeric chaparral vegetation. Billings (1950) has described the interesting occurrence of *P. ponderosa, P. jeffreyi* and other montane coniferous species on chemically altered andesitic soils in western Nevada. The climate of the area is too arid for these species under normal soil conditions, and supports only sagebrush or piñon-juniper vegetation. However, the sagebrush and most other shrubs cannot tolerate the chemically altered soils, and Billings has concluded that the absence of shrubby competitors enables the pines to persist.

The upward migration of *P. ponderosa* is, in all probability, usually

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[1] Professor G. Ledyard Stebbins (personal communication) has observed extensive mixed stands of *P. ponderosa* and *P. jeffreyi* in the North Coast Ranges. The stands in this area apparently comprise an exception to the usual pattern of restricted mixed stands in the north and extensive ones in the south.

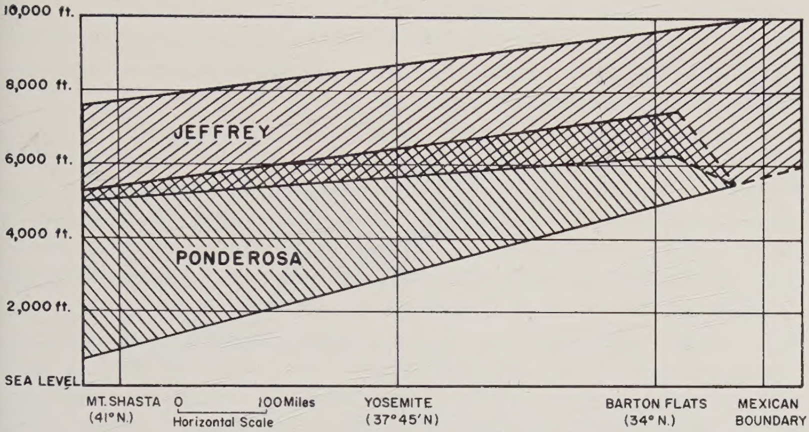

FIG. 1. Altitudinal distribution of *Pinus ponderosa* and *P. jeffreyi* along a north-south transect in California.

checked by low temperature. Californian *P. ponderosa* is killed by freezing when grown in areas with low winter temperatures, such as the Rocky Mountains (Weidman, 1939). I have observed frost damage on young individuals of *P. ponderosa* in California after periods of severe cold. The limiting effect of the low temperature undoubtedly works on the seedlings or young trees, because mature stands of *P. ponderosa* at its upper altitudinal limit are vigorous and show no evidence of being stunted.

Assuming that moisture and low temperature are the principal limiting factors for *P. ponderosa* at its lower and upper limits respectively, it is apparent from climatic data why *P. ponderosa* has a narrower altitudinal range in the south than in the north. As one travels south in California, precipitation generally decreases more rapidly than temperature increases at any given altitude (U.S. Weather Bureau, 1958). In other words, the isohyets gain altitude faster than the isotherms toward the south, leaving an ever shrinking zone that is favorable to the growth of *P. ponderosa*. It might be wondered, if the above is true, why *P. ponderosa* stops so abruptly in San Diego County rather than continuing toward the south over a decreased altitudinal range. There is no abrupt environmental shift at Cuyamaca Lake, and there are sites farther south that appear to be capable of supporting *P. ponderosa*. The reasons for the relatively sharp southern limit of the species may be historical. For example, a severe drought could have eliminated *P. ponderosa* south of where it occurs now, and the species may not yet have had sufficient opportunity to expand and reach its former extent.

Pinus jeffreyi is probably limited at the upper margin of its altitudinal range by a complex of factors all basically caused by low temperatures. Individuals growing near the upper limit of the species are often severely stunted in appearance, and obviously are showing the effects of the harsh climate. In addition, the upper limit of *P. jeffreyi* almost exactly parallels that of *P. ponderosa* from north to south in California, suggesting that different degrees of the same factors are limiting both species at the upper margins of their altitudinal range (fig. 1).

The lower altitudinal limit of *P. jeffreyi* does not appear to be determined by any obvious physical factors, but rather by competition with *P. ponderosa* or other species. *Pinus ponderosa* grows faster under cultivation than *P. jeffreyi* in many diverse localities, from the Institute of Forest Genetics at Placerville, California (within the range of *P. ponderosa*), to England (Hooker, 1884). Near its upper limit *P. ponderosa* may not grow much faster than *P. jeffreyi* and thus permit the occurrence of mixed stands, but lower down, the more vigorous growth of *P. ponderosa* could exclude *P. jeffreyi* since both species have about equally high light requirements (Sudworth, 1908). The much greater extent of stands containing both species in southern California than farther north might be due to a slightly lowered vigor and subsequent lessening of the competitive ability of *P. ponderosa* in the south. In relatively dry southern California, *P. ponderosa* is in an environment where moisture is more likely to be limiting than in the north, and therefore might be expected to be less vigorous. The occurrence of *P. jeffreyi* in areas where *P. ponderosa* is lacking is further evidence of the limitation of *P. jeffreyi* by competition. In southern San Diego County, beyond the southern limit of *P. ponderosa, P. jeffreyi* often occurs through the entire altitudinal range of the montane forest. A short distance to the north, the lower portions of this forest are occupied by *P. ponderosa* instead. In the Sierra Nevada there are numerous sites within the montane forest, often at very low altitudes, such as sandbars in rivers or areas of serpentine soil, where *P. ponderosa* occurs infrequently if at all. The less demanding *P. jeffreyi,* however, is frequently encountered on these sites.

Revealing evidence concerning the distribution limits of *P. ponderosa* and *P. jeffreyi* has been obtained from east-west transects across the mountains as well as by north-south transects along their axes. As an example, I shall describe a west to east transect across the Sierra Nevada in the vicinity of Yosemite National Park in central California. The western and eastern slopes of the central portion of the Sierra Nevada display a striking series of contrasts, both topographically and climatologically. The western slope is fairly gradual, receives from 30 to 60 inches of precipitation annually in the montane forest belt (U. S. Weather Bureau, 1958), and has a relatively mild climate characterized by temperature extremes that are not pronounced. The eastern slope, on the other hand is very precipitous, receives only 10 to 20 inches of annual precipitation in the montane forest belt because of the rain shadow effect produced by the 13,000 foot crest that lies to the west, and has a continental climate with great extremes of temperature.

At the latitude of Yosemite (38° N.), the lowest continuous stands of *P. ponderosa* appear at an elevation of about 3000 feet, where the mean

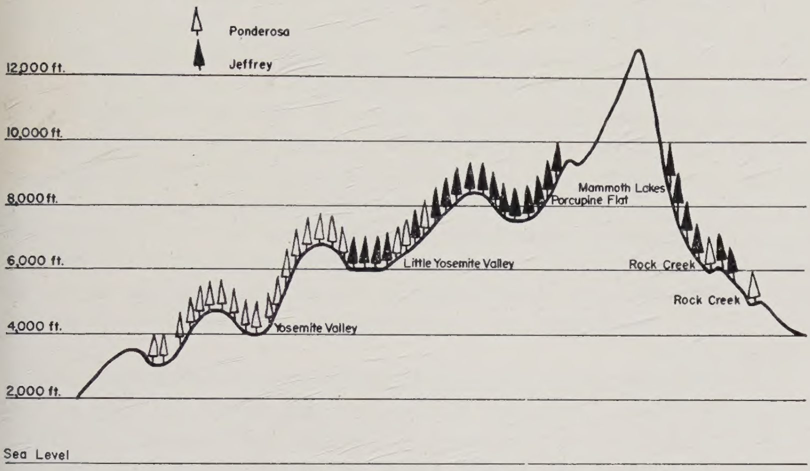

FIG. 2. Altitudinal distribution of *Pinus ponderosa* and *P. jeffreyi* along an idealized west-east transect across the central Sierra Nevada. Open triangles represent *P. ponderosa*; solid triangles represent *P. jeffreyi*.

annual precipitation is at least 30 inches. At about 6000 feet, *P. jeffreyi* is first found in abundance. The stands of *P. jeffreyi* growing at this relatively low altitude are usually not scattered at random over the slopes, however, but are concentrated near the margins of meadows or along streams, together with *Pinus contorta* subsp. *murrayana* Engelm., which occasionally occurs below its usual range in such places. *Pinus ponderosa* remains abundant for several hundred feet above the low places where *P. jeffreyi* is first encountered, especially on south-facing slopes, before giving way to *P. jeffreyi*. Above 6500 or 7000 feet, *P. jeffreyi* occurs alone and continues up to an elevation of approximately 9000 feet (fig. 2).

If the transect is continued across the 13,000 foot crest to the more arid eastern slope of the Sierra Nevada, *P. jeffreyi* will again be found below the 9000 foot elevation. Below 7000 or occasionally 6000 feet, where the annual precipitation may be as low as 10 inches, *P. jeffreyi* gives way to more xeric species, such as *Pinus monophylla* Torr. and *Artemisia tridentata* Nutt. *Pinus ponderosa* is not at all common on the eastern slope, and occurs without exception only along the banks of a few perennial streams. It is most abundant along Rock Creek near the Inyo-Mono county line at altitudes ranging from 5000 to 6500 feet (fig. 2).

The distribution pattern of *P. ponderosa* and *P. jeffreyi* along this west to east Sierran transect appears to be the result of the same limiting factors as those suggested by their north-south distribution. Although the lowest extensive stands of *P. jeffreyi* on the western slope of the Sierra Nevada are usually near meadows or along streams, the trees are probably not there because they need the moisture, but rather because *P. jeffreyi* is more tolerant of cold than is *P. ponderosa*. These low pockets where *P. jeffreyi* occurs are colder than the surrounding slopes in winter. The occasional presence of the usually subalpine *P. contorta* subsp. *murrayana* in these pockets is further evidence of this fact. Probably *P. jeffreyi* merely tolerates the extra moisture present at its lowest localities, because, as already noted, the species occurs in much drier localities in other areas. In the harsh climate of the eastern slope of the Sierra Nevada, *P. ponderosa* survives only at low elevations where it is not too cold and along streams where it is not too dry. Where *P. ponderosa* and *P. jeffreyi* are found in the same general area on the eastern slope, the latter, in contrast to *P. ponderosa* often occurs both near the streams and on the adjacent slopes.

Pinus ponderosa is found in abundance on both sides of the Sierra crest from Lake Tahoe northward. However, in this region the crest of the range is much lower than farther south, and the environmental differences between the western and eastern slopes are not nearly as great. On the desert-facing slopes of the higher mountains of southern California, *P. ponderosa* is again restricted to unusually moist localities.

SUMMARY

Pinus ponderosa and *P. jeffreyi* are important components of the California montane forest. *Pinus ponderosa* generally occurs on the lower coastal slopes, while *P. jeffreyi* generally occurs on the higher coastal or interior slopes. The distribution of *P. ponderosa* is usually checked by lack of moisture at low altitudes and by low temperature at high altitudes. *Pinus jeffreyi* is also limited by low temperature at high altitudes, but at its lower margin the distribution of the species is apparently limited primarily by competition with *P. ponderosa*. The extensive mixed stands of *P. ponderosa* and *P. jeffreyi* in southern California where *P. ponderosa* may be less vigorous than in the north, might be the result of decreased competition from *P. ponderosa*. *Pinus jeffreyi* is more tolerant of extremes of low temperature and aridity than is *P. ponderosa*, and is at least equally as tolerant as *P. ponderosa* of extremes of high temperature and high moisture.

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University of California at
Santa Barbara

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VIVIPARY IN CORDYLINE AUSTRALIS HOOK.

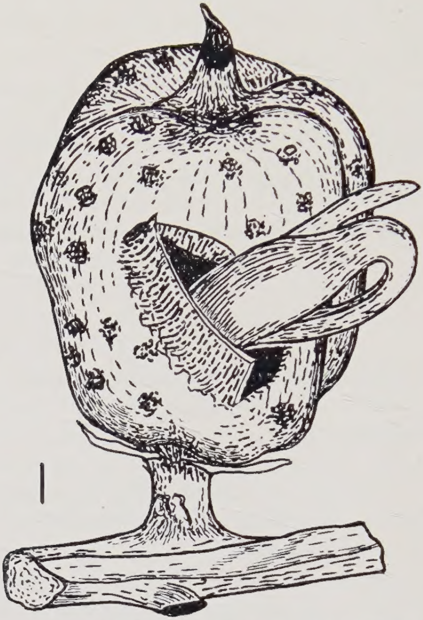
HOWARD J. ARNOTT

Vivipary is defined by Jackson (1928) as ". . . . germinating or sprouting from seed or bud, while attached to the parent plant." Examples of vivipary are known in a number of genera of both the monocotyledons and dicotyledons. The classical example of this condition occurs in such mangroves as *Rhizophora mangle* Blanco. In this species when the seed germinates while still attached to the parent plant, the hypocotyl-radical elongates, forming a long sharp structure (Daubenmire, 1947, fig. 10, p. 64). When this seedling structure becomes heavy enough, it breaks away from the parent plant and drops into the mud below. Because this sharp hypocotyl-radical structure penetrates the mud the seedling often becomes anchored and is prevented from being washed away from its environment, especially in the intertidal zone.

In the Agavaceae of Hutchinson, of which *Cordyline* is one member, several genera have been reported to show vivipary. Both *Agave* and *Furcraea* are included in this category. The viviparous condition in *Furcraea* is a great deal different than that of *Rhizophora* or *Cordyline*. In *Furcraea* at certain points along the inflorescence bulbils are formed. These bulbils (aerial deciduous buds) consist of a series of papery and photosynthetic bud scales surrounding a short axis and a shoot apex. These structures are often formed in enormous numbers and literally cover the ground when they abscise from the parent inflorescence. Bulbils begin to grow immediately when proper conditions prevail; plants produced in this manner have a very rapid rate of early growth.

In a cultivated plant of *Cordyline australis* Hook. growing in Berkeley, California, many cases of vivipary were observed. The bright-green young seedlings were easily seen protruding out of the white fruits. A total of over fifty separate fruits were found exhibiting this character.

In most cases the cotyledonary arch and the first leaf were all that could be seen of the seedling outside the fruit. Two cases were observed in



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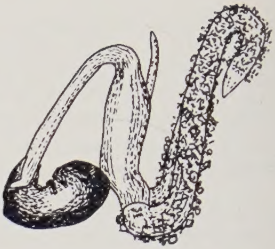

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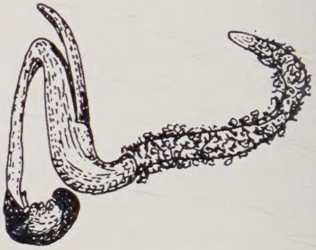

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FIG. 1. Fruit of *Cordyline australis* Hook. showing a viviparous seedling protruding through the ruptured fruit wall. The fruit was still attached to the inflorescence. The densely stippled areas on the fruit represent the purple pigmented areas which normally occur on the white fruit of this species. × 9.

FIGS. 2 and 3. Seedlings dissected from viviparous fruits showing the seed, the cotyledon, the first leaf, and the primary root. The primary root is intimately associated with the internal tissues of the fruit (see text). × 4.

which the seed was pulled free of the fruit by the elongation and straightening of the cotyledon. Figure 1 shows a fruit in which the "aerial" parts of the seedling have protruded through the fruit wall. This protrusion was effected by a rupture of the tissues which enclosed the seed. The area surrounding the rupture seems to be at most only slightly discolored. In some cases dissection showed more than one seed to be present inside the fruit, but no cases of "multiple-vivipary" were found.

Figures 2 and 3 show seedlings dissected from "viviparous" fruits. The shiny black seed attached to the haustorial cotyledonary tip can be seen with the photosynthetic and sheathing parts of the cotyledon extending out in an inverted "U". Below the cotyledon is the axis and the primary root.

The most interesting point observed in these cases was the very intimate relationship between the internal tissues of the fruit and the primary root of the seedlings. This intimacy seems to be caused by the penetration of the internal fruit tissues by root hairs. When one tries to dissect these seedlings free of the fruit it is almost impossible to separate the primary root from the internal tissues. It was not determined whether the root hairs grow between cell walls, into intercellular air spaces, or actually penetrate into the cells. The "fuzzy" appearance of the primary roots in figures 2 and 3 is an attempt to show this intimate association of the primary roots, root hairs, and internal fruit tissues after dissection.

One fact which seems to indicate that the root hairs are indeed the cause of this intimate association is that the root apex and some short distance behind it are completely free from any connection with the fruit tissues. This apparently is due to the absence of root hairs on such an immature part of the root.

Viviparous seedlings at a later stage than that shown in figure 1 have not been observed *in situ*. Such seedlings when removed from the fruit and placed on moist filter paper in a covered petri dish quickly show the production of new roots from the hypocotyl region. Apparently if these seedlings were planted they would produce normal plants.

While a number of cases of vivipary were found in this *Cordyline* plant, the number would be less than 0.1 per cent of the total number of fruits on the plant. One wonders what special physiological conditions were present in these viviparous fruits which caused or allowed the germination of these seeds. Also in the cases where more than one seed was present in a viviparous fruit, one wonders why only one seed germinated. One final question would be whether this condition occurs in this species in its native New Zealand, and what possible adaptive value might be found there for this condition, if it does occur.

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STUDIES ON SECOTIACEOUS FUNGI VI. SETCHELLIOGASTER POUZAR

Rolf Singer and Alexander H. Smith[1]

As a result of studying the types of *Secotium tenuipes* Setchell, and *Secotium aurantium* Zeller, we believe it is logical to group these two in a single genus as designated in our title. They have the following characters in common: their spores are some shade of rusty ochraceous, have an imperfect but often distinctly discontinuous pore-region, are elongate in shape, and smooth or ornamented by plugs of material filling canal-like passages through the wall. The hyphae bear clamp connections at the cross-walls and the mature gleba does not become pulverulent. The outer layer of the peridium is a layer of enlarged to vesiculose cells. The hymenophoral trama (tramal plates of the gleba) is regular, but in the region next to the subhymenium it is composed of characteristically enlarged cells often taking the shape of sphaerocysts.

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[1] Papers from the University of Michigan Herbarium and the Department of Botany, No. 1086, University of Michigan, Ann Arbor, Michigan.

The subhypogeous habitat, its presence in the forest duff in mild climates, the presence of gastroid basidia and spores, and possibly the bright color (or the absence of pigment) in the peridium are also features of the genus, but these characters do not necessarily separate it too sharply from other secotiaceous genera.

The spore characters and the structure of the outer layer of the peridium are very distinct from those of *Secotium* as represented by the type, *S. gueinzii,* and do not allow these species to be placed in any other segregate of *Secotium*. The generic name *Setchelliogaster* was proposed by Pouzar for the type species (*Secotium tenuipes* Setchell) just after we had submitted for publication our own account in which a new generic name was proposed for the two species treated below; therefore we have had to adapt our paper to the use of Pouzar's name, *Setchelliogaster*.

SETCHELLIOGASTER Pouzar, Ceská Mykologie 12:33. 1958.

Spores varying from light brownish to dark rusty ochraceous, with a germ pore which is mostly distinct, more rarely imperfect (or at least spore wall at apex of spore partly discontinuous), elongate, smooth or with an ornamentation of the type of *Metraria insignis* (part of spore wall conspicuously heterogeneous consisting of a continuous wall through which extend minute canals plugged by a resinous substance, these plugs appearing as dots or lines or imperfect reticulation on the paler ground when spore surface is focussed upon); clamp connections present; peridium covered by an epithelium; hymenophoral trama regular but showing some inflated elements and spherocysts near the subhymenium. Peridium russet brown or orange or rarely ivory color; gleba brownish; columella percurrent; stipe not voluminous. Basidium-spore-configuration of the gastromycetoid type. Among thermophilous vegetation, growing subhypogeously in humus under trees.

Type species of the genus: *Secotium tenuipes* Setchell.

SETCHELLIOGASTER TENUIPES (Setchell) Pouzar, Ceská Mykologie 12:34. Figs. 1–3. 1958. *Secotium tenuipes* Setchell, Jour. Mycol. 13:239. 1907.

Gastrocarp 10–30 mm. tall, and 10–30 mm. broad, subglobose or broadly ovoid, subumbonate, at the base more or less truncate.

Peridium membranous in lower (marginal) portion, up to 1 mm. thick further up, and rather thick at the point of confluence with the columella, glabrous, not viscid, yellow-brown, deep brown (according to Setchell), or red-brown ("Morocco red" R. according to Zeller), usually dehiscent from the stipe-columella to expose a narrow ring of gleba.

Gleba variable in structure, loculate with very regular (in shape and position) chambers which become slightly lammellarly extended near the exposed portion below, in other specimens generally with a gill-like structure especially visible in longitudinal sections of the gleba, and then consisting of anastomosing plates resembling those of *Polyporus alveolarius* but not in a regular manner and not permitting the shedding of spores, chambers sinuous or equal or completely irregular, gleba decurrent on the apex of the stipe-columella but for the most part dehiscent or free from the latter, ochraceous brown.

Stipe variable in length, reaching 20 mm., relatively thin, often bent or flattened, more or less concolorous with the pileus, striate, solid, equal or slightly attenuate downward, 2–3 mm. thick; columella continuous with stipe, percurrent and widened into the upper portion of the peridium, sometimes slightly narrowed before reaching the junction, lower portion to over half the lower length free from gleba; volva none; veil superior, arachnoid, transverse, scanty, evanescent after maturity is reached. Context fleshy, odorless.

Spores 14.5–19 × 9.5–12.5 μ, ellipsoid to subovoid, shape in optical section slightly more ventricose on the outer line than on the inner one, but without a suprahilar applanation or depression, and not so strongly asymmetric generally as in agaric spores, deep rusty ochraceous viewed in KOH, structure of wall complex at maturity and 1–1.2 μ thick. Perisporium conspicuous and pale ochraceous-tawny. Exosporium heterogeneous, consisting of a continuous wall through which extend minute canals plugged by a resinous golden tawny substance, these canals at the surface of the perisporium appearing as dots or elongated irregular lines which may be fused to form an imperfect inconspicuous reticulation which appears tawny on a paler background, under mechanical pressure the combined exosporium and perisporium tending to separate from the episorium. Episporium tawny and appearing as a thin line. Endosporium interior to the episporium, thick and much paler in color than the latter. Spore apex complex and peculiar in structure: germ pore generally either poorly developed or absent but at times a perforation clearly visible, with a tawny-cinnamon, plug-like, thick, heterogeneous (different from wall-material) body in the region where the pores should be (abnormal spores often with 2–5 such structures), at times showing a slightly mucronate apical callus but no distinct perforation (a discontinuity of the wall strata may be observed only in the endo- and episporium), not truncate at apex, not necessarily germinating through the apex (lateral germination observed).

Basidia 30–40 × 7–10 μ, (1–) 2– (3–)-spored, hyaline, numerous but rarely seen to form a large area of hymenium but rather intermixed with very numerous pseudoparaphyses, with a median constriction; sterigmata apical, straight or very slightly curved (not typically half-sickle-shaped but rather of gastroid type); pseudoparaphyses normally vesiculose and not projecting beyond the general level of the hymenium, hyaline, sometimes gigantic (cystidia?), about 32 × 16 μ, generally 20–22 × 13 μ; true cystidia or pseudocystidia none seen.

Subhymenium well-developed, subhyaline to hyaline, consisting of small irregular elements, some of them subisodiametric, forming a distinct if not very thick layer; hymenophoral trama consisting of brownish to brownish-hyaline hyphae of very variable diameter, some of them actually subisodiametric (e.g. 4–28 µ diam.), thin-walled or nearly so, some elements incrusted by deep rusty pigment, generally regular but chains of broad inflated elements alternating with strands of filamentous narrow hyphae, making the trama slightly intermixed, and reminding one of the gill trama of *Conocybe*. Peridial tissue thin, inner layer much like the hymenophoral trama, not gelatinous, its hyphae 5–27 µ broad; outer layer thick, its elements rusty brown from incrusting pigment, an epithelium or pseudoparenchyma consisting of spherocysts in chains or isolated, and few filamentous hyphae ending up (as a terminal member) in a spherocyst (spherocysts 8–28 (50) × 8–22 µ) hyphae of all tissues with clamp connections.

Subhypogeously on earth and humus under *Eucalyptus globulus, Quercus* sp., etc., in California, U.S.A., fruiting during the rainy season (Nobember until April), in Oregon also in June.

Material studied. CALIFORNIA. Alameda County: University of California campus, Berkeley, Dec. 12, 1904, *Gardner 229* (holotype, UC 221827), MICH. Topotypes: 25 March 1911, *Nichols,* MICH, NY (distributed as UC Herbarium Exsiccata 399); March 10 and April 11, 1911, *Harper,* NY; fall, 1923, *Parks,* NY; April 10, 1935, *Copeland* (det. E. E. Morse), NY; February and March, 1931, *Morse,* NY. Santa Clara County: Alma, March 2, 1919, *Parks Z9,* NY; Stanford University campus, March 5, 1942, *Cooke* & *Doty 16619,* MICH. Also material preserved at FH from same regions as above. OREGON: Corvallis, *Zeller,* NY.

Illustrations: Setchell (1907), pl. 107, figs. 4–8. Lloyd, Myc. Notes V:788, fig. 1184. Heim, Rev. Myc. 25:21. 1950. figs. 1–18.

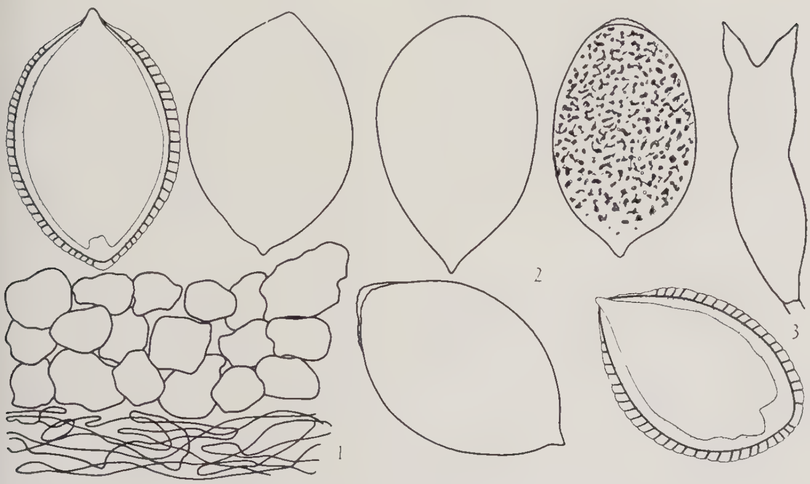
Setchell, in his original description, mentions the doubts he felt when publishing this species in *Secotium*: "In appearance and structure, this species varies so much from *S. Guienzii,* the type of the genus, that it may well be doubted whether it will ultimately be considered cogeneric with it, but, at present, it seems best to refer it to *Secotium* rather than attempt to split up that genus." We, on the other hand, find it rather amazing that between 1907 and 1957, in over half a century of mycological progress, no such attempt has been made.

Setchelliogaster aurantium (Zeller) Sing. & Smith, comb. nov. *Secotium aurantium* Zeller, Mycologia 39:292. 1947.

Gastrocarp 14 mm. broad, 15 mm. high, rounded umbonate above; peridium thin, not breaking from stipe-columella, bright orange, capucin yellow at base, gleba with small cavities, light brown.

Stipe terete, up to 3 mm. in diameter (about 20 mm. long), white, smooth, stuffed; columella also white, thin, percurrent; mycelium forming white rhizomorphs at base reminding one of those of the phalloids. Context white.

Spores 12–13 × 7.5–8 µ, light brownish ochre, smooth, ellipsoid to ellip-



Figs. 1–3. *Setchelliogaster tenuipes*: *1,* epicutis of peridium, × 450; *2,* spores, × 1000; *3,* basidium, × 450.

soid-fusoid, with many tiny oil droplets inside, with moderately thickened wall composed of at least two layers, the outermost one well-colored, but perisporium not noticeable and no ornamentation seen, symmetric, with a distinct germ pore in a continuous wall showing lighter different material, but not distinctly showing an opening, and not truncate.

Basidia 21–22 × 8.2 μ, with slightly oblique, conical, slightly curved sterigmata; pseudoparaphyses numerous, 19–20 × 12.5 μ; cystidia none seen.

Hyphae of the hymenophoral trama hyaline, the mediostratum regularly arranged and consisting of a strand of parallel or subparallel rather broad axillarly arranged hyphae, bordered on both sides by layers of spherocysts which become gradually smaller as the subhymenium and hymenium are approached, hyphae of the mediostratum 4–16.5 μ thick, spherocysts about 28 × 22 μ; peridium consisting of hyphous elements which are hyaline and 3–16 μ thick, outermost layer of peridium divided from trama proper by a hypodermium-like layer which is not very sharply differentiated from both the outermost layer and the internal hyphous layer, but consists of spherocysts or broad swollen hyphae forming a pseudoparenchymatous tissue which, on its outer side carries a palisade of clavate to irregular, more or less erect to isodiametric elements with remarkably thick lemon-yellow walls (walls 1.5 μ thick), the claviform ones about 22 × 10 μ; all tissues with clamped hyphae.

On the ground, apparently in the forest, fruiting in summer, Cuba.

Material studied. Cuba, Santa Clara Prov. July 6, 1941, *W. L. White 803* (NY & FH), type.

This species differs from the other member of the genus in the structure of the spore wall which lacks any ornamentation, but the important character of the outer layer of the peridium places the species in this genus. The microscopic data given in the description are taken from the type, but most of the macroscopic data are from the original description.

There is no other genus of secotiaceous fungi known at present with a cellular outer peridial layer such as found in either of these two species. *Weraroa* has a different peridial structure and its spores have a broader truncate apex.

As for the affinities of this genus with representatives of the Agaricales, we would say that it is even more closely related to the family Bolbitiaceae than *Galeropsis* which lacks a cellular outer layer of the peridium. While the habit is definitely more reminiscent of *Conocybe* in *Galeropsis* than in *Setchelliogaster,* the latter has also some similarity with such species as the fleshier *Agrocybes, Conocybe intrusa,* etc. The species with ornamented spores may be compared with such forms as are now combined in the subgenus *Ochromarasmius* of *Conocybe* where there is also a somewhat protruding germ pore. As a smooth-spored species, *Setchelliogaster aurantiacum* would be comparable with some of the more thin-walled representatives of *Conocybe* such as have been described in Kühner's monograph. The color of the peridium in this species does not seem to be rare in *Conocybe*. Finally, the relatively voluminous hyphal elements making up the hymenophoral trama are distinctive both for this species and in *Conocybe* where they may serve as a generic character separating this genus from the neighboring genera of the family Bolbitiaceae. It may be added that careful observation always reveals the existence of numerous pseudoparaphyses in the hymenia of *Setchelliogaster* as well as in *Conocybe* and *Bolbitius*. The spores of *S. tenuipes* are sometimes observed to be forked or otherwise misformed or doubled. Such monstrosities are common in the genus *Conocybe* and also in some other bolbitiaceous genera.

In spite of all the congruence found between *Setchelliogaster* as a whole and the Bolbitiaceae as a whole, it cannot be denied that there are also features in this genus which recall similar features of agarics in other families such as the particular spore ornamentation of *S. tenuipes*. This remarkable structure was noticed by Singer (1951) and attention was drawn to the partly agaric-like characters. Although the species was then characterized as agaricoid, no attempt was made to link it up with any particular group of agarics, a task which has become easier now that more species of *Secotium* have become known more thoroughly.

The ornamentation of *Setchelliogaster tenuipes* is not exactly duplicated by any known bolbitiaceous species. It is found, with slight variations, in *Ganoderma* among the "polypores", and in widely separated species and groups of species of the Agaricales such as *Boletellus, Metraria, Fayodia* (a genus considered as part of *Mycena sensu lato* by A. H. Smith), by a species described as *Tubaria thermophila* by Singer, and another described as *Kuhneromyces alpinus* by Smith.[2] A similar spore type has been observed by us in the type of *Secotium eburneum* Zeller, but at present we do not wish to transfer that species to *Setchelliogaster* because the cellular layer of the peridium is overlaid by a layer of gelatinous filamentous hyphae forming a pellicle which is the outermost layer of the peridium.

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CEANOTHUS SEEDS AND SEEDLINGS ON BURNS

CLARENCE R. QUICK[1]

Blue Canyon, the large rocky canyon of Big Creek, a tributary of Kings River, lies in the Sierra Nevada just southeast of Shaver Lake, Fresno County, California. This canyon once supported a magnificent stand of timber and in spots still does. Portions of the northerly part of the canyon were logged with "steam donkeys" around 1915. The ecologic course of reforestation on logged or burned forest areas, especially on high-quality forest sites, is often interesting and significant. Causes for variations in the reforestation process are not fully understood even yet.

The areas of Blue Canyon logged in 1915 were clear-cut, but somehow the methods used in the logging, the weather cycle after the logging, or perhaps other and unrecognized factors caused the cutover area to regenerate timber species promptly, especially sugar pine. For a while the new growing forest was somewhat brushy, but the brush slowly gave way to the competition of the trees, mostly pine trees, and by 1945 the old cutover area in the northeast corner of Blue Canyon was a beautiful stand of pole-sized sugar pine, ponderosa pine, white fir, and incense-cedar. Sugar pine predominated in much of the stand. Some decadent brush persisted, largely in the forest openings. On a one-acre study plot in the northwest corner of section 14, T10S, R25E, were found some 180 sugar pines, mostly pole-sized trees 4 to 12 inches in diameter.

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[2] This latter seems to be congeneric with *Melanomphalia nigrescens* and *M. platensis.* Singer (1955) placed *Melanomphalia* in the Cortinariaceae, and (1957) proposed the combination *Melanomphalia alpina* (Smith) Sing.

One hot afternoon in August 1947 a sawmill near the bottom of Blue Canyon (at an altitude of about 3,500 feet) caught fire and burned. The fire escaped and spread over 4 to 5 square miles of forest in the northeastern part of Blue Canyon. The fire was stopped near the rim of the canyon at an altitude of about 6,000 feet. The one-acre study plot was completely burned—all conifers and, for that matter, all plant parts above the ground surface were killed. Burned forest extended roughly for a mile in all directions from the plot.

In 1948 some small plots were established on the burned one-acre plot to see what plants were "coming back" on the burn. Ten separate milacre plots were distributed over the old one-acre plot. (A milacre—one-thousandth of an acre—is a square with sides of 6.6 feet.) Current-season seedlings which came up in the spring of 1948, the first spring after the burn, and resprouts from subsurface parts of plants which survived the burn were counted and recorded.

From the 10 milacres were removed 281 seedlings of Mariposa manzanita (*Arctostaphylos mariposa* Dudley), 1,204 seedlings of Sierra Nevada gooseberry (*Ribes roezli* Regel), and 1,994 seedlings of deerbrush (*Ceanothus integerrimus* H. & A.). This is a total of 3,480 seedlings of these three brush species on 10 milacres (1/100 acre).

From a single milacre were removed 83 manzanita seedlings; from another, 612 gooseberry seedlings; and from still another, 1,814 deerbrush seedlings. Subsequent checks of these milacre plots showed that no current-season seedlings of these three species came up in 1949 or in 1950. No conifer seedlings appeared on the milacre plots, and almost none within the boundaries of the old one-acre plot.

This ability to germinate suddenly after fire is characteristic of the seeds of several genera of shrubby plants in California; see, for example, Jepson (1925). Species which react in this way are commonly called firetype plants. Seeds of firetype species are mechanically durable, long-lived, and come to be relatively ubiquitous in the forest floor of the Sierra Nevada. Quick (1956) has shown that large numbers of many kinds of seeds are "stored" in the duff even under virgin stands of timber. Quick (1935) has also shown that treatment in boiling water plus stratification will condition seeds of many species of *Ceanothus* L. for immediate germination.

The longest treatment in boiling water of the experiments reported in 1935 was 5 minutes. This treatment resulted in very satisfactory germination in some species, and it was obvious that the limit of tolerance of some collections was not closely approached. So the question arose, just how much exposure to boiling water, for example, will *Ceanothus* seeds endure?

To seek an answer, samples consisting of 100 airdry seeds of deerbrush and of mountain whitethorn (*Ceanothus cordulatus*) were treated in the Berkeley laboratory by tossing them into a screen sieve suspended in vigorously boiling tap water. After treatment, the sieve and seeds were removed from the boiling water, soused in cold water, planted in autoclaved river sand, stratified to obviate embryo dormancy, and germinated in a greenhouse. Samples of seed collection Q#026 (deerbrush, collected on the South Fork of Stanislaus River at about 4,800 feet altitude) were treated in boiling water for 1 to 20 minutes. Twelve per cent of these seeds germinated after having been boiled for 20 minutes. Samples of seed collection Q#239 (mountain whitethorn, collected near Strawberry, Stanislaus National Forest, at about 5,400 feet altitude) were treated for 5 to 30 minutes in boiling water. Twenty-five per cent of these seeds germinated after being boiled for 25 minutes, but none germinated after being boiled for 30 minutes. A manuscript, now nearing completion, will analyze statistically the seed germination reactions of several species of *Ceanothus* with respect to seed age, altitude of seed collection, length of exposure to boiling water, and temperature and length of stratification treatment.

Many seeds, even *Ceanothus* seeds, are destroyed in any forest fire, but the above preliminary experiments suggest that seeds of many firetype plants are very durable, long-lived, and sufficiently resistant to high temperatures to escape destruction and to completely revegetate a heavy burn. Thus starts the first stage in a new cycle of forest development.

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CHROMOSOME NUMBERS OF CALIFORNIA PLANTS, WITH NOTES ON SOME CASES OF CYTOLOGICAL INTEREST

RICHARD SNOW

Meiosis has been examined in microsporocytes of various species of Californian plants, and the resulting chromosome numbers are listed in Table 1. During the course of these observations several meiotic phenomena have been observed that have cytological interest beyond chromosome number. These will be discussed briefly in order to point out some areas possibly worthy of further study.

METHODS. Buds were fixed in 1:3 acetic-alcohol for one to several days and stored in 70 per cent alcohol under refrigeration. After soaking in water for a few minutes the material was softened in 1N HCl at 60°C. for 5–10 minutes, rinsed with water, and the anthers squashed in aceto-orcein or aceto-carmine. The *Fritillaria* material was stained by the Feulgen reaction. Permanent slides were made by Bradley's (1948) method, without removing the coverslip.

TABLE 1. DOCUMENTED CHROMOSOME NUMBERS OF CALIFORNIA PLANTS[1]

SPECIES	CHROMOSOME No. (2n)	LOCALITY AND COLLECTOR
Fritillaria biflora Lindl.*	24+0–8ff	Near Saddle Peak, Santa Monica Mts., Los Angeles County, *Lewis* in 1958.
Delphinium polycladon Eastw.	16	Rodger's Lake, Tuolumne County, *Snow 284.*
Ranunculus californicus Benth.	28+f	Road from Bridgeport to Highway 140, Mariposa County, *Snow* and *Wedberg* in 1953.
Eschscholtzia mexicana Greene	12	15.3 miles north of Goffs on the road to Lanfair, San Bernardino County, *Snow 18.*
Thelypodium lasiophyllum (H. & A.) Greene	48	Red Rock Canyon, Kern County, *Snow 410.*
Isomeris arborea Nutt.*	40	2.7 miles west of Whitewater, Riverside County, *Raven 11409.*
		Point Dume, Los Angeles County, *Snow* (no specimen).
		Red Rock Canyon, Kern County, *Snow 407.*
Lupinus superbus Hel. var. *elongatus* (Greene) C. P. Smith*	48	Matterhorn Canyon, Tuolumne County, *Snow 292.*
Astragalus Bolanderi Gray	22	Badger Flats, near Huntington Lake, Fresno County, *Snow 62.*
Astragalus leucopsis (T. & G.) Torr.	22	Point Dume, Los Angeles County, *Raven 13857.*
Astragalus oocarpus Gray	22	4.6 miles north of Santa Ysabel, San Diego County, *Raven* and *Snow 9557.*
Astragalus pomonensis Jones	22	1.7 miles west of Dripping Springs Guard Station, Riverside County, *Raven* and *Snow 9543.*
Astragalus crotalariae Benth.	24	Salton Sea State Park, Riverside County, *Raven 11484.*
Datisca glomerata (Presl) Benth. and Hook.	22	Banning-Idyllwild Road near Grand View Guard Station, Riverside County, *Raven* and *Snow 11115.*
Epilobium obcordatum Gray	36	Little Slide Canyon, Mono County, *Snow 275.*
Oenothera californica Wats. var. *californica**	28	11 miles east of Riverside, Riverside County, *Snow* and *Mosquin 318.*
Gayophytum racemosum T. & G.	14	Little Slide Canyon, Mono County, *Snow 273.*
Monardella odoratissima Benth.	42	Little Slide Canyon, Mono County, *Snow 272.*

[1] Voucher specimens and prepared slides are in the Herbarium of the University of California, Berkeley.

* See discussion in text.

f = fragment chromosome.

Species	Chromosome No. (2n)	Locality and Collector
Datura meteloides DC.*	24	See Table 2.
Plantago insularis Eastw.	8	Near Red Rock Canyon, Kern County, *Snow 416.*
Pedicularis groenlandica Retz.	16	Pass between Little Slide Canyon and Slide Canyon, Tuolumne County, *Snow 276.*
Proboscidea Jussieui Keller	30	Putah Creek, west of Davis, Yolo County, *Snow 605.*
Senecio Fremontii T. & G. var. *occidentalis* Gray*	40+f	Little Slide Canyon, Mono County, *Snow 270.*

My thanks are due Dr. Harlan Lewis for the buds of *Fritillaria biflora,* and to Mr. Peter Raven for the material of *Astragalus crotalariae* and for permission to cite his unpublished observations on *Isomeris arborea.*

Cytological Notes

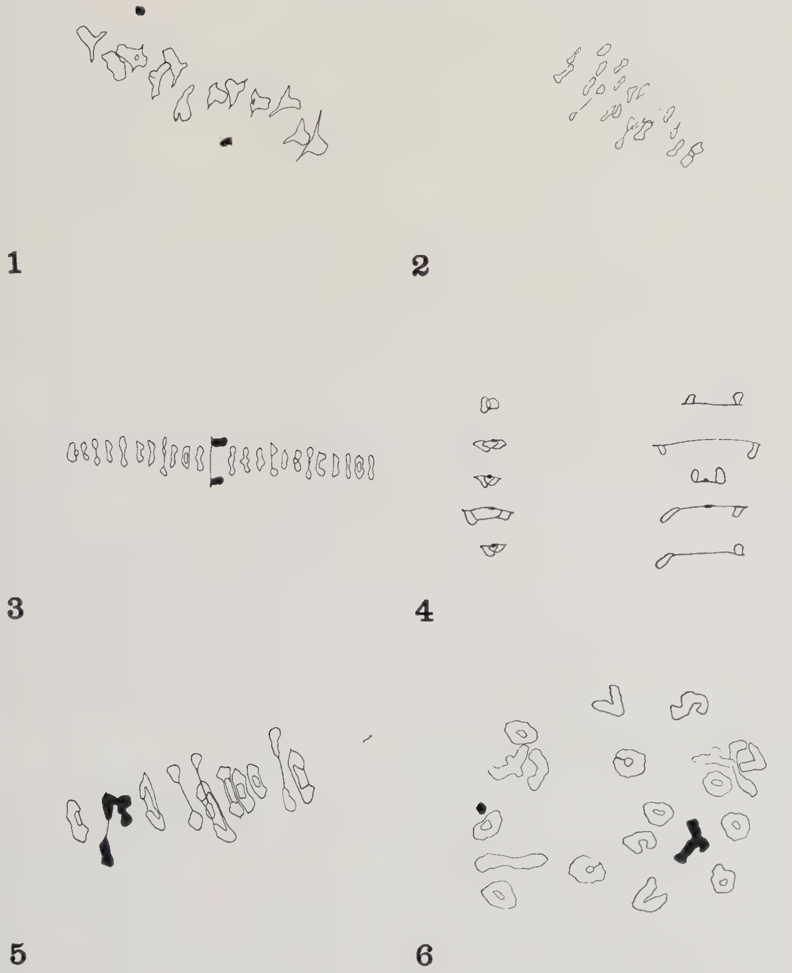
FRITILLARIA BIFLORA. The fragments in this species are one-third to one-fourth the length of the long arms of chromosomes of the basic complement at anaphase II. It is not certain how constant their number is from plant to plant, since buds from several plants were fixed in the same vial. However, since this species has usually only two to four flowers per plant it is almost certain that each bud in a meiotic stage was derived from a different plant. The number of fragments found in various buds from this collection was 2, 4, 6, or 8. There was also occasionally a smaller variation in number from one PMC to another within the same bud.

At metaphase I from 1 to 4 "fragment-pairs" have been seen in various buds (fig. 1), and no fragments have been seen at this stage which were not "paired." These dual associations may represent the synapsis of homologous fragments or the division of unpaired fragments. The few mitotic cells on the slides were not clear enough for a definitive answer. The fragments do not congress to the metaphase plate with the other bivalents, but instead usually lie off in the cytoplasm above or below it. Their position at metaphase I may account for their frequent inclusion in the daughter nuclei. However, lagging of the fragments is not infrequent at anaphase. At anaphase I a fragment-pair may separate, one or both halves being included in a nucleus; or the pair may be included, without separation, in one daughter nucleus. As a result of lagging and irregular separation, an anaphase nucleus may receive from none to as many fragments as the PMC contains. Anaphase II distribution is likewise variable. Irregularities of division possibly also occur in mitosis, and may account for the variation in the number of fragments observed in different PMCs of the same bud.

Anaphase observations suggest that the fragments probably possess a centromere, though one which is perhaps less efficient in division than normal. An area which is probably the centromere region appears subterminal in mitotic cells. The preparations were not especially good for study of this feature, however, but certainly the fragments gave no indication of being isobrachial. They do not, therefore, appear to be products of mis-division of a centromere followed by the uniting of sister chromatids to convert a telocentric into an iso-chromosome, as has been found in the triploid *Fritillaria latifolia major* by Darlington (1940; see also Darlington, 1939). Whatever their origin it seems likely that all the fragments observed in the various buds (and hence from several plants) are the result of a single primary event of the past, both because their similar form and because the formation of nuclei with extra fragments as a result of non-disjunction offer cytological evidence of a means for their increase. Pollen grains with fragments are no doubt functional at least occasionally, if we may extrapolate from the results of Kayano (1956), who found almost a 1:1 ratio of 2n:2n+f plants in the cross *Lilium callosum* 2n ♀ × 2n+f ♂. In this case the fragment appears to be a telocentric from an originally acrocentric supernumerary. As in *F. biflora,* however, no pairing of the fragment with the basic set occurred at metaphase I, though several fragments could pair among themselves.

The western Amercan species *F. lanceolata, F. pudica, F. recurva* and *F. folcata* are reported to have fragment chromosomes (Beetle, 1944; La Cour, 1951). In addition, Darlington and Wylie (1955) list several Old World species, and also the Californian species *F. pluriflora,* as having B chromosomes; these may be the same type as those present in *F. biflora*. It is possible that such chromosomes are present throughout the genus, in some species frequent, in others rarer. What their role may be in the population dynamics and evolution of the species remains to be determined.

ISOMERIS ARBOREA. This plant has enjoyed a measure of fame since Billings (1937) reported it to be haploid with a highly anomalous embryology. Since then several workers have reinvestigated the embryology and found it to be essentially normal, although with certain peculiar features (Maheswari and Kahn, 1953; Sachar, 1956). The chromosome situation, however, has not yet been clarified. Observations of meiosis made by Mr. Peter Raven of a plant growing near Whitewater, Riverside County, and by the author of one plant from Point Dume, Los Angeles County, and of another from Red Rock Canyon, Kern County, have shown the species to be a diploid with 20 pairs of chromosomes (fig. 2). The chromosomes are small and difficult to stain well, and buds in meiosis are found rather infrequently, so that it is not favorable material cytologically. However, these observations have shown a normal meiotic sequence from diakinesis through telophase II. Further, my examination of pachytene showed two paired strands in clear cells, and in a few instances where the synapsed chromosomes were more widely separated than usual they could be seen to have a similar chromomere pattern. From the figures published by Billings, it seems clear he observed normal meta-



FIGS. 1–6. Chromosome plates. 1, *Fritillaria biflora*: 12 bivalents plus 2 "fragment-pairs"; 2, *Isomeris arborea*: 20 bivalents; 3, *Lupinus superbus* var. *elongatus*: 24 bivalents, the largest with unequal arms; 4, *Lupinus superbus* var. *elongatus*: left, five A bivalents at metaphase or early anaphase, right, five A bivalents at anaphase; 5, *Datura meteloides*: 10 bivalents plus a chain of 4 chromosomes; 6, *Senecio Fremontii* var. *occidentalis*: 20 bivalents plus 1 fragment.
(Fig. 1, × 358; Fig. 2, × 952; Figs. 3–6, × 1071.)

phases and anaphases in both of the meiotic divisions, but as he was convinced that only univalents were present at diakinesis, he interpreted these as equational separations of univalents.

Isomeris arborea must therefore be returned to the category of rather ordinary plants.

LUPINUS SUPERBUS var. ELONGATUS. At metaphase 24 bivalents are present. One of them is conspicuously larger than the rest, and I designate it the A bivalent (fig. 3). In the pollen mother cells from one inflorescence this bivalent was unequal, that is, one chromosome was shorter than the other. Judging from metaphase appearances the A chromosomes are probably acrocentric, and regularly form a chiasma in the short arm. In about ten to twenty per cent of the cells the longer (unequal) arms also show evidence of a chiasma. Figure 4, right, shows the appearance of 5 A bivalents with a chiasma in the short arm; figure 4, left, 5 with chiasmata in both arms. It is possible that the A chromosomes usually form a chiasma in each arm, and that early terminalization in the longer arms releases them from their association. This is suggested by the fact that clear one-chiasma bivalents appear further along in anaphase separation than those with two chiasmata.

White (1954) has given a diagram showing the various types of meiotic segregations which have been observed or are presumed to occur with unequal bivalents of orthopteroid insects. The segregation at the first division will depend upon three factors: the position of the centromere, the position of the chiasmata, and the position of the inequalities. His diagram is based on two assumptions: that the extra segment is terminal rather than interstitial, and that only one chiasma is formed in the unequal bivalents. White has based these two assumptions on the evidence presently available from grasshoppers and phasmids. In *Lupinus superbus* we have what appears to be an example of an interstitial inequality in an unequal bivalent where chiasmata are formed in each arm, a situation for which White had no examples. The evidence for the existence of more than one chiasma in the A bivalent is unequivocal: two-chiasmata bivalents have been seen in many metaphase cells. The evidence for the interstitial position of the inequality is less direct. It depends on the fact that only reductional separations of the inequality have been observed in both one-chiasma and two-chiasmata A bivalents. Should a chiasma be formed in the long arm proximal to a terminal inequality, then an equational separation would result, with one chromatid of the anaphase chromosome longer than the other. Such equational separations were never observed in about fifty cells analyzed, although it must be admitted that equational separations might not be readily detected, since the chromosomes are rather small. Furthermore, only terminal junctions have been found in the unequal arm of the A bivalent at metaphase, while a chiasma proximal to an inequality would be expected to remain interstitial at this stage. It thus appears that reductional separation of the inequality is the rule, and hence that it occupies an interstitial position in the chromosome arm. Whether it is a duplication, a deficiency, or a heterochromatic region (as is so often the case in insects), has not been determined.

Two other chromosomal types might be expected in the population, namely the corresponding homozygotes. The size difference between the A chromosomes is great enough so that there should be no difficulty distinguishing them. First metaphase was studied in another inflorescence (and hence probably from another plant). In this case both members of the A bivalent appeared about the same size, and were as large as the larger member of the heterozygous plant. If the inequality is a deficiency, the homozygote for the smaller member may not be viable. A much larger sample of the population would be desirable in order to determine the prevalence of the three types, and to compare their frequencies with the expectation based on the Hardy-Weinberg formula.

OENOTHERA CALIFORNICA var. CALIFORNICA. The plant examined of this collection was a tetraploid (n=14). A varying number of pairs and rings of four chromosomes was found at diakinesis and metaphase, the maximum seen being six rings of 4 plus 2 pairs. The pairing observed suggests that this species was derived from a diploid form which formed 7 bivalents. In *Oe. californica* var. *glabrata,* Lewis et al. (1958) reported two associations of 8 chromosomes, indicative that the diploid form might have been a structural heterozygote. These observations on *Oe. californica* (subgenus *Anogra*) parallel those of Hagen (1950) on two tetraploid species of the subgenus *Raimannia,* who found only pairs or rings of 4 in *Oe. tetragona,* but long chains (of up to 14 chromosomes) and univalents in *Oe. speciosa* var. *Childsii.* In this latter species, diploids are known which form one or two rings of 4, or 7 bivalents.

As is usual with multivalent configurations in the Onagraceae, adjacent chromosomes were regularly segregated to opposite poles at anaphase, thus supporting Garber's (1954) suggestion that if a diploid species shows directed segregation of chromosomes from interchange configurations, the autotetraploid will likewise show directed segregations of the quadrivalents. These observations coincide with those of Catcheside (personal communication to Garber, l.c.) that "*Oenothera* tetraploids from structurally homozygous diploids show almost regularly zigzag orientation of the rings of four." As a consequence of such regular segregation and the lack of lagging chromosomes, fertility in this tetraploid should be quite high.

DATURA METELOIDES. Ten wild plants of this species have been examined and five have been found to be heterozygous for a reciprocal translocation (table 2). A sixth (from Caliente Creek) suggests by frequent univalent formation that it may also be heterozygous for a structural change which is unidentified at present. The plants are apparently not all heterozygous for the same interchange, because a plant from Isabella Reservoir and plants from Putah Creek (*Snow 322–5, 324–5*) characteristically formed rings of four at metaphase, while in the Yucaipa plant (*11076B*) only chains of four were observed. In a third Putah Creek plant (*Snow 322–1*) variable configurations were formed at metaphase. Usually the groups of four chromosomes appeared as a branched chain (fig. 5). Sometimes one of the pairs of chromosomes of the configuration had a chiasma in each arm, so that the association resembled a kite with the

TABLE 2. LOCALITIES AND METAPHASE ASSOCIATIONS OBSERVED IN WILD INDIVIDUALS OF DATURA METELOIDES

LOCALITY AND COLLECTOR	METAPHASE ASSOCIATIONS
Near Ensenada, Baja California, Mexico, *Snow* (no specimen).	12(2)
Near Yucaipa, Riverside County, *Raven* and *Snow 11076A*.	12(2)
Near Yucaipa, Riverside County, *Raven* and *Snow 11076B*.	10(2)+(4c)
Caliente Creek, Kern County, *Snow 248*.	12(2) or 11(2)+2(1)
Isabella Reservoir, Kern County, *Snow 253*. (coll. 6/18/54).	10(2)+(4r)
Isabella Reservoir, Kern County, *Snow 253A*. (coll. 7/30/57).	12(2)
Putah Creek, south of Davis, Yolo County, *Snow 322–1*.	10(2)+(4c) or 10(2)+(4r)
Putah Creek, south of Davis, Yolo County, *Snow 322–5*.	10(2)+(4r)
Putah Creek, south of Davis, Yolo County, *Snow 322–8*.	12(2)
Putah Creek, west of Davis, Yolo County, *Snow 324–5*.	10(2)+(4r)

(2) = bivalent (1) = univalent
(4c) = chain of four (4r) = ring of four

tail coming off one side. Other configurations observed, much less frequently, were a "T" with a univalent, a non-disjunctional ring of 4, and 12 bivalents.

Staiger (1955) has found interchanges in natural populations of the mollusc *Purpura lapillus* which lead to metaphase configurations similar to those which I have found in one plant (*Snow 322–1*). He has shown how they may be accounted for by the interchange of short end pieces of metacentric chromosomes plus variations in chiasma formation. The same scheme can account for the configurations in this plant of *Datura meteloides*. The translocations in other plants probably represent larger exchanges of chromosome end segments.

Four chromosomal arrangements have been found in this species by Satina (1953), and one of them (type I) has been compared to the standard race of *Datura stramonium*. The other three arrangements presumably differ from type I by reciprocal translocations. The type I arrangement has been found in twenty-eight races. Unfortunately the origin of none of these races is cited in the paper, so that the geographical distribution of this type is unknown. Furthermore, the existence in nature of individuals heterozygous for reciprocal translocations was not reported for *D. meteloides,* and apparently has not been for any other species of *Datura,* even though individuals of the same species may be homozygous for different chromosome arrangements while members of different species invariably are.

Study of *D. meteloides* is being continued with the view of discovering the role translocations may play in the populations.

SENECIO FREMONTII var. OCCIDENTALIS. The extra chromosome in this material is a small fragment about one-fourth the length of an arm of the longer chromosomes of the complement at diakinesis. At this stage it is often found lying in the proximity of a bivalent with widely diverging arms, one of which appears shorter than the other by about the size of the fragment. The fragment may even appear attached to this arm by strands of stainable material. With about an equal frequency, however, it is found completely free of this readily-recognizable bivalent (fig. 6).

Stages later than diakinesis were not favorable for study in these preparations. In a few metaphase cells which could be analyzed, the fragment was attached to a bivalent, probably a continuation of a diakinetic association which was so often observed. The fragment was included in one of the daughter nuclei in all instances save one. In this one instance, out of about fifty cells in telophase examined, the fragment had been excluded and was dividing.

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CHROMOSOME COUNTS IN THE GENUS GAYOPHYTUM[1]

David G. Dixon

Gayophytum, an annual member of the family Onagraceae, consists of sixteen recognized taxa grouped into eight species. The genus, founded in 1832 by A. de Jussieu on a South American plant, *Gayophytum humile* Juss., is confined to narrow ecological niches along the cordillera of North and South America from Canada to Cape Horn, with an interval in Mexico and Central America where it has not been reported. It has not been found outside the mountain ranges of the western Americas.

As a genus, *Gayophytum* is very poorly known owing to the small size of the plants, the insignificant flowers (rarely as large as 5 mm. across), and the relative difficulty of obtaining specimens. The plants have linear-oblanceolate leaves and very slender, diffusely branched stems. The ultimate branchlets are often filiform and bear numerous tiny four-petaled flowers in the upper axils. The bushy habit of the plants often with a great number of branching thread-like stems gives them a fuliginous aspect, and when in flower, the blossoms appear to be floating near the ground, hence the popular common name "Ground Smoke."

The flowers are perfect, actinomorphic and tetramerous. The sepals are in the orthogonal and the petals in the diagonal planes. Ovaries are bilocular and inferior, with ovules in one row in each loculus. The fruit is dry, splitting loculicidally and septifragally so the inner portion of the fertile carpels is left as a seed-bearing column in the center (Saunders 1940).

Gayophytum may be distinguished from the very similar *Epilobium* by the lack of coma on the seeds, by the two-celled ovaries and fruits, and by having solitary pollen grains.

Plants of *Oenothera* of similar size and habit and with equally reflexed sepals may be distinguished from *Gayophytum* by their more elongate hypanthium and four-celled ovary. The prevailing flower color of *Oenothera* is yellow; the flowers of *Gayophytum* are white, turning rose-purple with age.

In the words of Munz (1932): "The genus *Gayophytum* offers an unusually interesting series of plants varying in a comparatively small number of characters, and these in every conceivable combination. Flowers may be small or large; capsules may be sessile or pedicelled, erect or spreading-deflexed, short or long, torulose or not torulose; the minute hairs may be appressed or spreading; seeds may be glabrous or pubescent; branching may be basal or distinctly above the base. The attempt at classification . . . may be quite artificial; it has been arrived at only after

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[1] A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Botany at the State College of Washington, 1957. The author wishes to express his appreciation to Dr. Adolph Hecht who suggested the problem, and served as advisor during the course of the research, and to Dr. Marion Ownbey who provided many suggestions during the preparation of the manuscript.

TABLE 1. CHROMOSOME NUMBER AND SOURCE OF GAYOPHYTUM COLLECTIONS STUDIED

SPECIES	CHROMOSOME No. 2n	SOURCE
G. Helleri var. *glabrum* Munz	14	Washington, Douglas Co.: 6 mi. N. of Withrow, Route 10-B, on *Artemisia* knolls, *Dixon 9.*
G. humile Juss.	14	California, Mono Co.: Carnegie Inst. Timberline Station, Slate Creek Valley, 10,000 ft. elev. *H. Lewis.*
G. lasiospermum Greene	28	Idaho, Valley Co.: 1 mi. S. of Lake Fork, Route 15, on coarse gravel of ditches, *Dixon 14.*
G. lasiospermum Greene	28	Idaho, Adams Co.: 4.5 mi. S. of New Meadows, on cut-over *Pinus ponderosa* flat, W of Route 95, *Dixon 17.*
G. Nuttallii T. & G.	28	Washington, Okanogan Co.: 5 mi. W. of Republic Route 4, on moist clay and gravel road-cut, *Dixon 7.*
G. Nuttallii T. & G.	28	Idaho, Valley Co.: within city limits of McCall, on sand banks, *Dixon 12.*
G. Nuttallii T. & G.	28	Idaho, Latah Co.: on roadside sand of Saddle between Twin Buttes, Moscow Mountain, *Rumely & Dixon.*
G. Nuttallii T. & G.	28	California, Tuolumne Co.: 4.4 mi. W. of Kennedy Meadows, Highway 108, Deadman Creek at 6,000 ft. elevation. *Balls & Everett 18074.*
G. Nuttallii var. *Abramsii* Munz	28	Washington, Stevens Co.: 2 mi. S. of Kettle Falls, Route 22, fine sand in *Pinus* flat, *Dixon 3.*
G. racemosum var. *erosulatum* Munz	28	Idaho, Valley Co.: 1 mi. S. of Lake Fork, Route 15, on coarse gravel road-bank, *Dixon 15.*

much study. Unfortunately geographical distribution which is so often a great aid to the systematist, is not very useful here, and one almost doubts the validity of some of the entities maintained because of lack of continuous or definite distribution. Furthermore, the floral parts are so minute that individual specimens can easily be thrown into the wrong group. Yet, as I have worked over many hundreds of sheets at various times . . . , I have been forced to conclude that there are several very real and definite entities in the genus."

The taxonomic treatments of Trelease (1893) and Munz (1932, 1951, 1952) have proved satisfactory and have been followed in this study. Trelease expressed the opinion that *Gayophytum* may be of rather recent differentiation from *Oenothera,* representing an accentuated montane-type.

A possible origin of *Epilobium* (n=18) by the "addition" of eleven chromosomes of *Gayophytum ramosissimum* T.&G. (n=11) to the seven of *Boisduvalia* (n=7) has been suggested by Johansen (1933). This view that *Epilobium* may be of hybrid origin, however, has not been supported.

Very little is known about the cytology of *Gayophytum.* Johansen's (1933) work on *G. ramosissimum* is the only published report of previous cytological study in this genus. It was with the objective of adding to the cytological information on this genus that the present study was undertaken.

Plants for this study were collected during the late summer months of 1955 and 1956, in eastern Washington, central and southwestern Idaho, and northeastern Oregon. Additional seeds were supplied by Dr. Harlan Lewis and by Dr. P. A. Munz. Dr. Munz kindly identified the plants used.

Plants of *Gayophytum nuttallii* T.&G. were grown to maturity in the greenhouse, but no other species survived past the seedling stage in cultivation. Root-tips were the source of the meristematic tissues used in this study.

Field collected root-tips were fixed in Belling's metaphase modification of Navashin's fixative. Paraffin sections cut at ten microns were prepared and then stained by the crystal violet-iodine method (Johansen, 1940).

Chromosome numbers of 2n=14 and 2n=28 were found in the plants studied. Johansen (1933) lists the number 2n=22 for the North American species, *Gayophytum ramosissimum.* The number 2n=28 was found to be constant in collections of *Gayophytum lasiospermum* Greene, *G. Nuttallii, G. Nuttallii* var. *Abramsii* Munz, and *G. racemosum var. erosulatum* Munz. The number 2n=14 was discovered in *Gayophytum Helleri* var. *glabrum* Munz and in *G. humile.*

On moistened filter-paper in Petri dishes kept at room temperature, seeds of the 14-chromosome species had a relatively vigorous germination percentage of 11 per cent, whereas those of the 28-chromosome species under the same conditions may have as low as one-fourth of 1 per cent germination.

The two 14-chromosome species were collected at elevations of 2,000 and 10,000 feet, respectively. The 28-chromosome species are from elevations ranging from 900 feet to over 6,000 feet. The 14-chromosome species tend to be smaller in stature and have smaller flowers than those with 28 chromosomes, but marked phenotypic differences are not evident between the two groups.

Discussion

It is suggested that the 14 chromosomes counted in *Gayophytum Helleri* var. *glabrum* and in *G. humile* may make up the basic diploid complement of the genus. If this is the case, it may be assumed that the species with 28 chromosomes constitute a number of tetraploid taxa. The chromosomes do appear in reasonably recognizable sets of four in these species.

The chromosome numbers reported in this root-tip study are not consistent with the 22 chromosomes reported for *Gayophytum ramosissimum* (Johansen, 1933) in which embryo-sac meiosis was examined. The species previously studied was not available for examination in the current investigation. The possibility exists of an aneuploid series of chromosomes in *Gayophytum*. The count of 22 might be an instance of a hyperploid $(3x + 1)$ constitution.

A brief survey of the chromosome numbers (Darlington and Wylie, 1956) in the family Onagraceae reveals a range of basic numbers occurring in *Clarkia* (including *Godetia*) ranging from $x = 5$ through 7, 8, and 9; *Gaura* may have $x = 7$ or 9. Other genera reported show $x = 7$ constant for Oenothera, $x = 8$ for *Jussieua*, $x = 11$ for *Circaea*, *Lopezia*, and *Fuchsia*, with $x = 15$ for *Zauschneria* and $x = 18$ for *Epilobium*.

It is apparent that *Gayophytum* fits most closely into the chromosome series of the family near *Oenothera*. Such a position would agree with Trelease's view (1893) that *Gayophytum* may be of rather recent differentiation from *Oenothera*.

SUMMARY

Mitotic chromosome studies were made on ten collections of six taxa representing five species of *Gayophytum*. Chromosome numbers of $2n = 14$ and 28 were found. The numbers 14 and 28 are in addition to the one of 22 previously reported for the genus.

Chromosome counts for *Gayophytum Helleri* var. *glabrum*, *G. humile*, *G. lasiospermum*, *G. Nuttallii*, *G. Nuttallii* var. *Abramsii*, and *G. racemosum* var. *erosulatum* are reported for the first time. Voucher specimens are on file in the herbarium of the State College of Washington.

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REVIEWS

Spring Flowers of the Lower Columbia Valley. By CLARA CHAPMAN HILL. Illustrated by Mary Comber Miles. pp. xi + 164. University of Washington Press. 1958. $3.00.

Certainly one of the most frustrating and interest-stifling experiences of a novice at plant identification is his attempt to name a plant by using the formidable terminology of the keys and descriptions of technical manuals. *Spring Flowers of the Lower Columbia Valley* is the newest of a small number of "easy" manuals which have been designed to accustom the beginner to this terminology and to the technique of using the more detailed and comprehensive manuals of the Pacific Northwest flora.

This small book is not, as its title suggests, a manual of the vernal flora of the lower Columbia River valley. Rather it is a florula of what might more appropriately be called the lower Willamette River valley in the vicinity of Portland, Oregon. It describes, in a simplified manner, about 200 of the more conspicuous herbs and shrubs of the season in that region. Use of technical words in the keys and descriptions is held to a minimum; a number of these terms are introduced by means of illustrative line drawings. Additional terms can be found in the glossary which, however, offers some definitions so oversimplified as to be quite uninformative. Approximately one-third of the species treated are adventive. Unfortunately no trees or ferns are considered, even though these groups often attract much attention from the beginners for whom this book was written. Following the introduction is a key to the genera; in the text the species are arranged under family headings and in some instances there are keys to the species within genera. The text is enlivened by brief but interesting notes on the natural history, uses, and lore of various species. Some of the families are characterized by short descriptions, a few of which are so truncated that they do not adequately distinguish one family from another. For example, the traits of the Saxifragaceae as stated could apply equally to the Crassulaceae for which no diagnosis is given. A problem common to all books which cover only a segment of a flora is the chance of misidentification by a beginner of a plant which appears to "key out" correctly, but is in fact unlisted in the book. Nevertheless, the selection of species considered is good, and few errors should arise providing it is used in the season and the region it is intended to cover.

The format, binding, and price are attractive; the nomenclature is up-to-date and the book seems virtually free of typographical errors. For summer and autumn work its owners should feel confident and experienced enough to graduate to other more technical manuals of broader scope, many of which are listed in a bibliography. However, even after they have gone on to other works, they will want to keep this book on the shelf for the occasional pleasure of leafing through it to savour the 71 superb, full-page line drawings by Mary Comber Miles. Perhaps these are its greatest recommendation.—ROBERT ORNDUFF, Department of Botany, University of California, Berkeley.

Spring Flora of the Dallas-Fort Worth Area [,] *Texas*. By LLOYD H. SHINNERS. v, 514 pp., 11 plates, 2 maps. Published by the author, Southern Methodist University, Box 473, Dallas 5, Texas. 1958. $4.75 (by mail, $4.85).

The author of this unusual book has been working since 1945 in an area for which there has never been a complete descriptive flora. It is a particularly interesting area because it centers about the Blackland Prairie which supports a large endemic and near-endemic flora, and because the tension zones lying east and west of the prairies here are complicated and have been little known in detail. The author's apologia explains a little of why this is still not a complete flora; this is worth quoting in some detail because it helps to point up one of the most unusual features of the book, namely the extent to which it is truly a production of the author's own work and thought:

> "Spring Floras are a peculiarly American institution. In almost any other country one would get a complete flora, not just a sample. I do not know for certain all the reasons for this, but most are not scientific. Expediency, laziness, indifference, incompetence, and imitativeness are all involved, along with distractions, lack of facilities and time, and the difficulties involved in writing a complete work in most parts of the country—which itself has never had a whole flora completed for it. This book is largely an abstract of my *Flora of North Central Texas,* which after thirteen years' labor is still unfinished. A major part of the delay is due to the fact that I have had during the same time to create the elaborate facilities needed to produce such a work. Some has been due to my conceit in determining at the start that everything would be written by myself, and based on live plants and specimens. Nothing was to be farmed out to specialists; only the absolutely unavoidable minimum would be taken from publications."

A little further along Dr. Shinners hints at the real justification for a Spring Flora; in his part of Texas the early spring is the only major season of bloom. The growing season may begin in January and reach a climax in February or early March; before the beginning of May the hot season has set in and everywhere the sun-dried skeletons of plants proclaim the onset of summer.

The book was written to be used. The keys avoid the use of obscure characters, and the terms used in them are simple and clear. In the descriptions an attempt has been made to combine brevity with emphasis on diagnostic features. A useful feature is the inclusion of common spring-flowering cultivated plants likely to be encountered in the area.

The author warns the reader, however, that he has not prostituted science for the sake of popularity:

> "There is no magic which will make it child's play to find out the names of so huge a quantity of variable plants. No real familiarity with them can be acquired without using technical terms. No worthwhile list of them is possible without using scientific names. If you wish something painless and effortless, the pursuit of botany is not for you. Nature gives away few secrets to the lazy, and none to the incompetent".

The total number of species considered in the Flora is about 1650, including three that are described for the first time. The largest families, not surprisingly, are the Compositae, Gramineae and Leguminosae. The key to families, if it works, will be a joy to the earnest student who has so often been frightened away from regional floras by keys that are replete with references to details of ovule structure, placentation and the like. Dr. Shinners' key, appropriately enough in a Spring Flora, is based entirely upon floral characters and vegetative characters. Some technically minded botanists may shudder at having *Galium,* Orchidaceae, *Lonicera japonica* and *Arisaema* associated in the key under the heading of HERBACEOUS DICOTS. I found it hard to use this part of the key. In numerous other trials in other parts of the key I found family after family readily identifiable.

The keys to genera represent something of an achievement, especially in the families like Cruciferae, Leguminosae, Umbelliferae and Compositae where generic differentiations have heretofore been based almost entirely on characters of the fruits. Other authors, of course, have attempted, like Shinners, to construct generic keys using floral characters only. The late Norman C. Fassett did this with signal success in the *Spring Flora of Wisconsin.* Fassett was dealing with 15 genera of Leguminosae; Shinners treats 48. Fassett had 13 genera of Compositae; Shinners keys out 64 genera without mentioning the mature achenes. Specialists may pick flaws in the treatments of their favorite groups, but it seems to me this is a praiseworthy attempt to focus attention upon floral characters that have usually been overlooked by botanists.

The author's concepts of families and genera are for the most part broad ones.

He makes of Leguminosae a single family, and Rosaceae another. His treatment of the Liliaceae-Amaryllidaceae group, although not out of line with modern thought, is not conservative. Perhaps his most startling departure from general practice is in the recognition of *Chamaesyce* as distinct from the rest of Euphorbia. His concept of the species (based primarily on consideration of morphology and geographic area, as he says on page 469) is a rather inclusive one that in general seems appropriate in the flora with which he is dealing. In *Crataegus,* for example, Shinners recognizes 14 species, relegating to synonymy (sometimes with a question) approximately as many additional species described by earlier authors. In *Rubus* Shinners recognizes 5 native species, listing in synonymy 12 additional species described by Bailey.

Throughout the book an appeal is made to the common-sense of the reader. Manufactured "common names" are avoided and indeed anathematized. Comments on exceptional nomenclatural situations, taxonomic oddities or complexities, and extraordinary or unusual features of the plants themselves, are frequently mentioned. Nomenclatural synonyms are included sparingly, chiefly for the sake of clarity when there have been recent changes in the application of names.

Following the formal systematic treatment of the flora, Dr. Shinners has included a series of plates illustrative of certain plant families, and finally a series of appendices explaining technical terms, the use of keys, the justification for a standard system of plant-nomenclature, and the preparation of herbarium specimens. There is a glossary and a short discussion of ecology, vegetational types and the botanical history of the region.

In general this is a very commendable book that will command a great deal of respect from amateur and professional botanists alike. It should be particularly effective as an introduction to Botany when used by the student, in or out of school, who is initially attracted by a flowering plant and wants to learn more about its identity and its characteristics. As a contribution to floristics the book is patently an introduction to the author's projected and much larger work. In its present form, hastily gotten out with a regrettably large number of typographical errors, it must be nevertheless regarded as a remarkably good and scholarly flora of an area where such a work was urgently needed. The book begins with a quotation from Gerarde's *Herball* of 1597, and this review may well close with a line from the Book of Daniel, long ago quoted by Olof Swartz in expressing his appreciation to those who contribute to floristic knowledge: *Plurimi pertransibunt et multiplex erit scientia.*—ROGERS MCVAUGH, University of Michigan, Ann Arbor.

NOTES AND NEWS

ALLIARIA OFFICINALIS ANDRZ. IN OREGON.—In the spring of 1959 a cruciferous plant which could not be identified in the regional manuals was collected in an undisturbed forested portion of the Reed College campus in southeastern Portland, Oregon (*Ornduff 5057*). This plant has proved to be the European garlic-mustard, *Alliaria officinalis* Andrz., which has not previously been reported from the Pacific states. The Reed College colony of this biennial species was composed of about two dozen freely seeding plants. It had not been recorded in a thorough, unpublished census of the campus flora made in 1938. Subsequently a second colony of about the same size was located in a wooded tract in southwestern Portland. This species is well established and widespread in eastern North America and appears well on its way to becoming a permanent member of the adventive flora of at least the Portland area as well.—ROBERT ORNDUFF, Department of Botany, University of California, Berkeley.